Distribution and Growth Patterns of Crab (*P. pelagicus*) Based on Environmental Characteristics in Candi Waters, Pamekasan Regency, East Java Province

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Abstract

Blue swimming crab (BSC) is a fishery commodity with high economic value and great demand in domestic and foreign markets. P. pelagicus swimming crabs are commonly found in Indonesian sea waters, one of the largest contributors to the country's foreign exchange after shrimp and tuna. The high demand for blue crab resources will trigger an increase in fishing efforts. If this is done continuously, it is feared that it could endanger the population structure. Moreover, disrupting the sustainability of blue swimming crab resources in the waters, this study examines the morphometric distribution and growth pattern of P. pelagicus crabs based on environmental characteristics in Candi waters, Pamekasaan Regency. Census sampling was carried out using the census method; the census method was carried out by taking all crab samples caught by fishermen. The results obtained found 33 individual crabs, which were divided into three classes, namely small (<10 cm), medium (>10 cm), and large (>12 cm) size classes. Male crabs dominated the research locations with wider straps than female crabs. The analysis results show that the width-weight relationship's b values are 1.47 (males) and 2.00 (females). In addition, male and female crabs have a positive allometric growth pattern. Blue swimming crabs are often found in habitats with a substrate of dusty mud, high salinity and organic matter.

Keywords: P. pelagicus, morphometric distribution, growth patterns, environmental characteristics, Pamekasaan Regency.

INTRODUCTION

Indonesian fisheries have great potential, one of which is fishery resources. One of the potential marine fisheries is the blue swimming crab (*P. pelagicus*) (Yusfiandayani & Sobari, 2011) (Setyawan dan Fitri 2018). The blue swimming crab (*P. pelagicus* Linnaeus, 1758) is a type of crab from the Portunidae family that lives in shallow waters up to a depth of 50 m with a substrate of silt, sand, and muddy sand (Asphama *et al.,* 2015; Madduppa *et al.* 2016; Prasetyo *et al.* 2019). Blue swimming crab is one of the important commodities that contribute to foreign exchange in Indonesia, whose production is obtained from Catching in Nature (Tirtadanu dan Suman 2018; Istikasari *et al,.* 2015)

The blue swimming crab (*P. pelagicus*) is an important commodity. It has a high economic value and domestic and international market demand (Kamrani *et al,.* 2010; Wulandari and Beosono 2014; Ernawati and Boer 2014; Adam, 2016) (Damora & Nurdin, 2016). The blue swimming crab (*P. pelagicus*) is a crustacean that includes food animals. This animal is also known as the blue swimming crab (Palupi *et al.* 2018) (Prabawaa *et al.,* 2014).

The high demand for crab resources will trigger an increase in fishing efforts by local fishermen (Budiarto *et al.*, 2015). Often fishermen catch without paying attention to KP Regulation Number 1 of 2015, which regulates crab fisheries' minimum legal size limit. Also, non-selective fishing gear can affect swimming crab communities and populations (Nofrizal *et al.*, 2018). If this is done continuously, it is feared that it could endanger the population structure and disrupt the sustainability of crab resources in waters. The Indonesian Crab Entrepreneurs Association stated that there was a decrease in the volume of crab exports in the 2018-2020 period by 20% (APRI, 2020).

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Management of fishery resources requires data related to the distribution and biology of biota. The distribution of blue swimming crabs is needed to determine the habitat of the blue swimming crab; the morphometric characters describe the conditions to determine changes in the morphological form of an organism. Morphometric characters are used to find information related to sex, classification of kinship relationships, and patterns of intra-species morphological diversity (Bahri Agus *et al.*, 2016; Rachmawati, 2009). Furthermore, the long-weight relationship and condition factors are important measurements in fishery biology. The length-weight relationship can be used as a character to distinguish a taxonomic unit and calculate condition factors. Each species will have a certain length-weight relationship. At the same time, the condition factor is used to see the welfare of a species between populations. Several factors influence condition factors, including feed availability and environmental variations (Rodriguez *et al.,* 2017).

This study aims to determine the distribution and growth pattern of blue swimming crab (*P. pelagicus*) based on environmental characteristics in Candi Waters, Pamekasaan Madura Regency. The results of this study are expected to be the basis for the government to make a policy, such as a ban on catching crabs in shallow waters, to create sustainable crab fisheries.

MATERIAL AND METHODS

This research was carried out in July 2022 in the coastal waters of Pamekasan Regency. Pamekasan Regency is one of 4 regencies located on Madura Island, which has an area of 792.30 km2 and is located at 6°51'-7°31' south latitude and 113°19'-113°58' east longitude. Pamekasan Regency is one of the regencies on Madura Island, East Java Province, which is known and nicknamed the salt island and has a large catch for fishermen. The study was conducted at four stations representing the crab fishing grounds; station 1 was located near the mangrove areas, residential areas, and ponds. Stations 2, 3, and 4 represented the crab-catching areas with different depths (Figure 1). Sample analysis and environmental parameters were conducted at the Environmental and Aquatic Productivity Laboratory (Proling), Faculty of Fisheries and Marine Sciences, Bogor Agricultural University.

Blue swimming crab data was taken using the census method, taking all samples of crab caught by fishermen (Suhernalis dan Rahman 2020). A 1-gill net with buoys, flags (markers), and weights is placed at each station. The net, measuring 1m x 40m with a mesh size of 3.5 inches, is stretched parallel to the shoreline towards the sea, with a distance of approximately 350 m between stations.

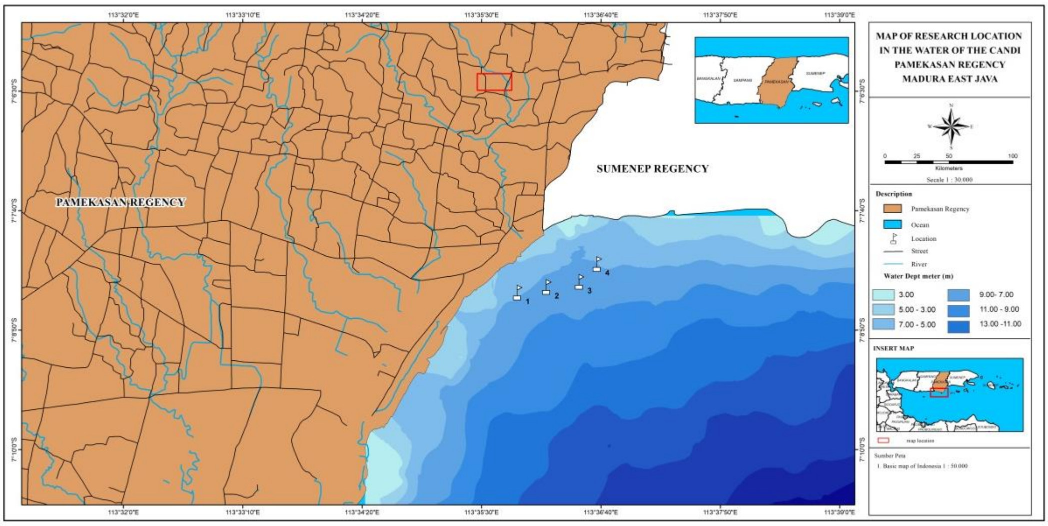

Figure 1. Research Location Map

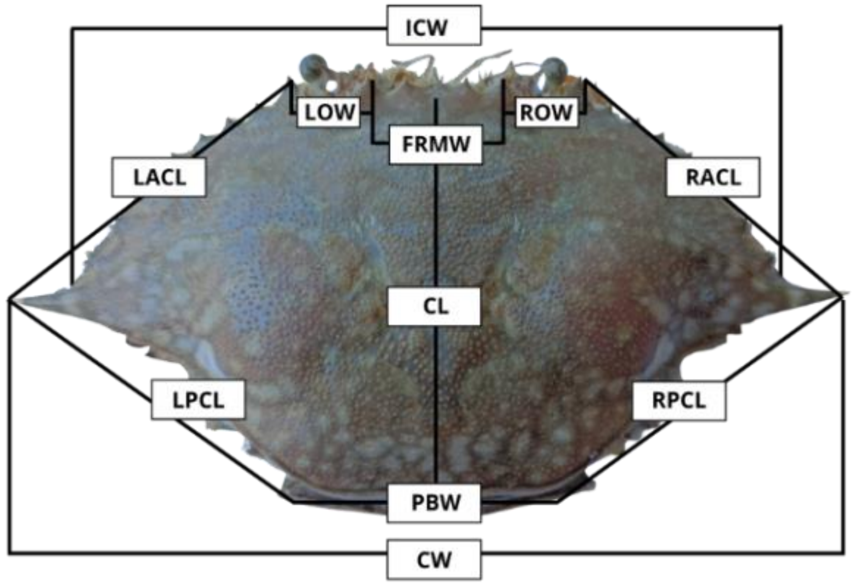

Figure 2. Crab Morphometric Characters 1. Carapace width (CW), 2. Internal carapace width (ICW), 3. Carapace length or height (CL), 4. Left anterolateral carapace width (LACL), 5 Right anterolateral carapace width (RACL), 6. Left carapace posterolateral length/height (LPCL), 7. Right carapace posterolateral length/height (RPCL), 8. Frontal spine width (FRMW), 9. Left orbit (LOW) distance or width, 10. Left orbit or width right orbit (eye socket) (ROW), 11 Posterior carapace width (PBW) (Fig. 2). The weight of individual crabs was measured using a digital scale (accuracy of 0.01 gram).

Data on the characteristics of the aquatic environment were obtained by measuring the parameters of water depth, water temperature, salinity, pH, and dissolved oxygen (DO) which were carried out in situ. In addition, sediment characteristics data were obtained through analysis of sediment samples conducted at the Laboratory of Environmental and Aquatic Productivity (Proling), Faculty of Fisheries and Marine Sciences, Bogor Agricultural University. Individual crabs caught and sampled were then identified for their sex, and their morphometric characteristics were measured. The morphometric characters of individual crochets were measured using a vernier caliper with an accuracy level of 0.01 mm, consisting of 11 (eight) characters (Figure 2).

Determination of crab size classes is done by: (1) determining the number of classes k = 1 + 3.322 log n, where n = the number of observations, and (2) determining the size of class (c), namely the maximum length minus the minimum length divided by the number of classes (Agustini, 2016). The growth pattern of a blue swimming crab is analyzed based on the relationship between length and weight through the equation (Ariyanto *et al.*, 2018).

$$W = aLb \qquad (1)$$

Note: W = observed individual weight and L = carapace length (mm), a and b = constants

The crab's plumpness is measured by the condition factor (Kn), which indicates the condition of the crab in terms of its biological capacity for survival and reproduction. The condition factor (K_n) is calculated using the following equation (Jisr *et al.*, 2018).

$$K_n = W/aL^b \qquad (2)$$

Note: K_n = the condition factor; W = the weight of the individual observed; L = the width of the crab carapace (cm); a and b = a constant.

The analysis of the distribution of crab morphometric characters at each station, Principal Component Analysis (PCA), was processed using the XL-Stat program. Parameters included in the analysis were percentages 1. Carapace width (CW), 2. Internal carapace width (ICW), 3. Carapace length or height (CL), 4 Left anterolateral carapace width (LACL), 5 Right anterolateral carapace width (RACL), 6. Left carapace posterolateral length/height (LPCL), 7. Right carapace posterolateral length/height (RPCL), 8. Frontal spine width (FRMW), 9. Left orbit (LOW) distance or width (LOW), 10. Right orbit (eye socket) distance or width (ROW), 11 Posterior carapace width (PBW) found at each station (Bengen, 2000).

The relationship between blue swimming crabs and environmental characteristics was analyzed using Correspondence Analysis (CA) (Bengen, 2000). The data matrix consists of crab size classes (in rows) and environment variables (in columns). This analysis was performed using the XL-Stat program.

RESULTS AND DISCUSSION

Sampel rajungan yang ditemukan sebanyak 33 individu dari keseluruhan stasiun penelitian yaitu 6 individu (Stasiun 2), 20 individu (Stasiun 3) dan 7 individu (Stasiun 4) yang terbagi menjadi 3 kelas ukuran, yaitu kelas ukuran kecil dengan lebar karapas (≤ 10 cm) sebanyak 6 individu, kelas ukuran sedang dengan lebar karapas (≥ 10 cm) sebanyak 14 individu dan kelas ukuran besar (≥ 12 cm) individu dari keseluruhan stasiun penelitian. Pola pertumbuhan Rajungan bisa dilihat pada Tabel 1.

The results of the calculation of the width-weight of the swimming crab, the male crab has an equation value of W=0.0291L3.319 with a determination coefficient R2 (0.9793), and a female crab W=0.0175L3.607 with a determination coefficient R^2 (0, 09409). Based on the value of the coefficient of determination, the research results obtained R^2, which shows whether there is a relationship between the total width of the crab weight, in which the value of R^2 is below 1, meaning that there is no relationship between the total width and the weight of the crab, on the contrary, the value of R^2 is close to 1 and 1, which means that the total width is very related closely (Ramses *et al.,* 2019). The results showed that the coefficient of determination (R^2) was close to 1 and 1, meaning that the total width is closely related to the weight of the crabs, the growth pattern is indicated by the value of b, in which the male and female crabs have a positive allometric growth pattern, meaning that the weight gain is faster than the carapace width.

Although the growth pattern of male and female crabs showed a positive allometric growth pattern, analysis of the condition factor (K_n) value of 2,00 indicated that the female crabs at the study site were fatter (plump) compared to the male crab, which had a condition factor (K_n) value of 1,47 (Table 1) this is influenced by several factors such as gonadal maturity level, food conditions, gender, environmental factors, and food abundance (Nasir *et al.* 2016; Listani 2016; King 2007; Hargiyatno *et al.* 2013). In addition, environmental parameters also affect the growth and abundance of blue swimming crabs; from the study's results, it was found that the temperature range at each research station was not significantly different, namely around 28-30˚C (Table 2). The temperature at the study site is good enough for metabolic and breeding processes. They were supported by previous research (Ernawati & Boer, 2014), where the optimal temperature can support the life of blue crabs.

Table 1. Constant b value, coefficient of determination (R^2), and condition factor (K_n) for blue swimming crab (*P. pelagicus*).

Blue swimming crab					
Male			Female		
b	R^2	K_n	b	R^2	K_n
3,39	0,97	1,47	3,67	0,94	2,00

Description: b: Growth coefficient, R^2: Determination coefficient, K_n: Condition factor

In addition to temperature, salinity (28-30 ppt), dissolved oxygen (5.40-8.00 mg/l), pH (7.90-8.20), total organic matter (TOM) (1.49-29, 52), depth (4-9 m) (Table 2) and type of substrate also affect the life of the blue swimming crab. The condition of the environmental parameters is slightly different at station 1; salinity, dissolved oxygen, and total organic matter were lower than at the other stations. The low salinity, dissolved oxygen, and total organic matter are because station 1 is near residential areas and ponds, so the river flows around the pond flows directly to station 1, which gets freshwater flow which is thought to affect the condition of dissolved oxygen salinity and lower total organic matter, so no crabs were found. This is in line with research conducted by (Radifa *et al.,* 2020; Apriliyanto *et al.* 2014; Madduppa *et al.,* 2017) that found more crabs in areas with high salinity compared to areas with low salinity.

The highest abundance of crabs was found at station 3, dominated by medium crabs having the highest abundance of 11 and/40m2 (Figure 3). Where station 3 has a dusty clay substrate, high dust, and clay substrates at the research station are located in calm waters, and ocean currents are not too large so that precipitation occurs higher, which causes the texture of the substrate to become finer so that the finer fraction can accumulate high organic matter compared to substrates that have coarser fractions such as sand and gravel, it can be seen that crabs that are medium and large and have good morphometric characters tall. PCA results of the distribution of crab morphometric characters at each research station (Figure 4). Data were obtained by measuring 11 blue swimming crab morphometric character ratios at each research station.

Table 2. Substrate composition and environmental parameters

St	DO (mg/l)	Temperature (℃)	Salinity (ppt)	TOM %	Dept (m)	pH Air	Sand %	Silt %	Clay %
1	5,40	30,00	28,00	1,49	4,00	7,90	4,56	76,70	18,70
2	7.60	29,00	30,00	13,24	7,00	8,20	6,70	78,10	18,00
3	8,00	28,00	30,00	29,52	9,00	8,00	2,89	79,60	17,60
4	7,90	29,00	30,00	16,61	8,00	7,90	2,99	77,70	19,30

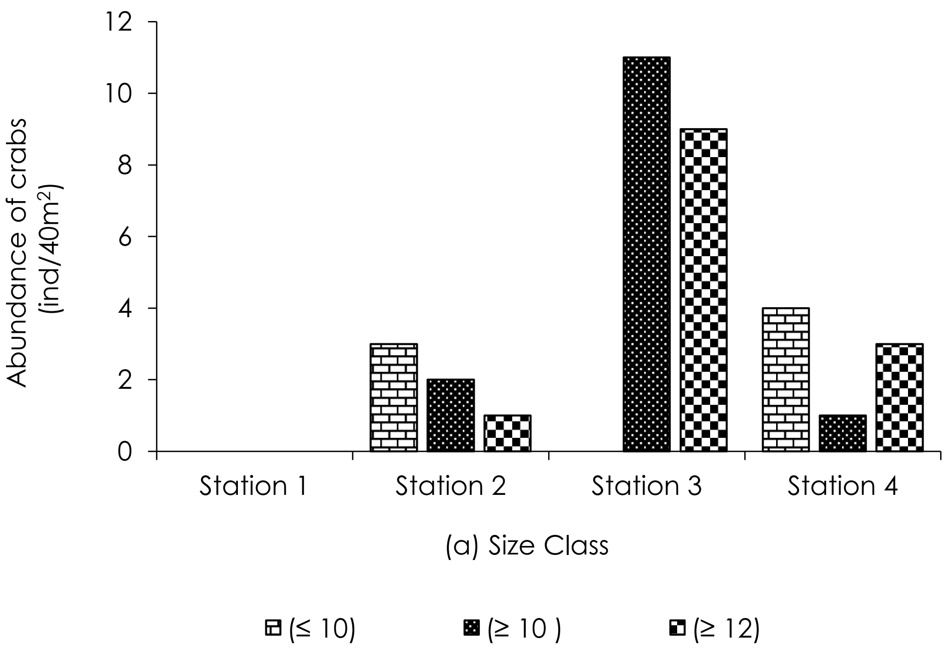

Figure 3. Blue swimming crab abundance (individuals/40m^2) at each research station based on size class

PCA results can be seen from (Figure 4) that the distribution of blue crab morphometric characters is centered on axis 1 (F1) with a diversity of 46.54% and axis 2 (F2) with a diversity of 12.35%. At station 3, the crab with the high morphometric character values was characterized by the crab having the widest carapace width compared to other stations, such as inner carapace width (ICW), carapace width (CW), carapace length or height (CL).), left carapace anterolateral carapace width (LACL), right anterolateral carapace width (RACL), left posterolateral carapace length/height (LPCL), right carapace posterolateral length/height (RPCL), orbit distance or width (eye socket) (LOW), and posterior carapace width (PBW) and weight. In contrast, stations 2 and 4 have low morphometric character values because the crabs found at stations 2 and 4 are generally small in size and have relatively low weight.

The relationship between blue swimming crab and water characteristics can be seen in Figure 5. The results of the correspondence analysis (CA) illustrate that there are 3 (three) groups of crab groups and environmental characteristics centered on axis 1 (F1) with a variance of 65.59% and axis 2 (F2) with a variance of 34.38% (Figure 6). Analysis of the relationship and environmental characteristics can be seen in Figure 6. The first group explained that large, medium, and small crabs at Station 4 were generally found on dusty clay substrates. The second group showed that large, medium, and small crabs found at Station 2 were at low depths (<8 meters), salinity (<29 ppt), and dissolved oxygen (<7.9 mg/l). Three showed that the medium and large crabs found at station 3 had relatively high habitats in deeper waters (> 7 meters), salinity (> 28 ppt), and dissolved oxygen (< 7.6 mg/l) at the study site.

The largest population of medium and large crabs was found at station 3, at a depth of 9 meters, inhabiting a dusty clay substrate and characterized by organic matter, salinity, and dissolved oxygen, which are crab habitats. Mud/clay substrate is a suitable habitat for crab life because it provides various types of food; the finer the texture of the substrate, the higher the organic matter content. For example, at the research location, small shellfish were found, in the substrate sample, as well as fish and lobsters that were netted, so it was suspected to be a contributor to organic matter and it was seen that at the research location; there were still quite good waters, with plump crabs found fat (fat). According to (Rustam *et al.*, 2018), the amount of organic matter in the waters comes from detritus, phytoplankton, or other biota waste products broken down by microorganisms around the waters.

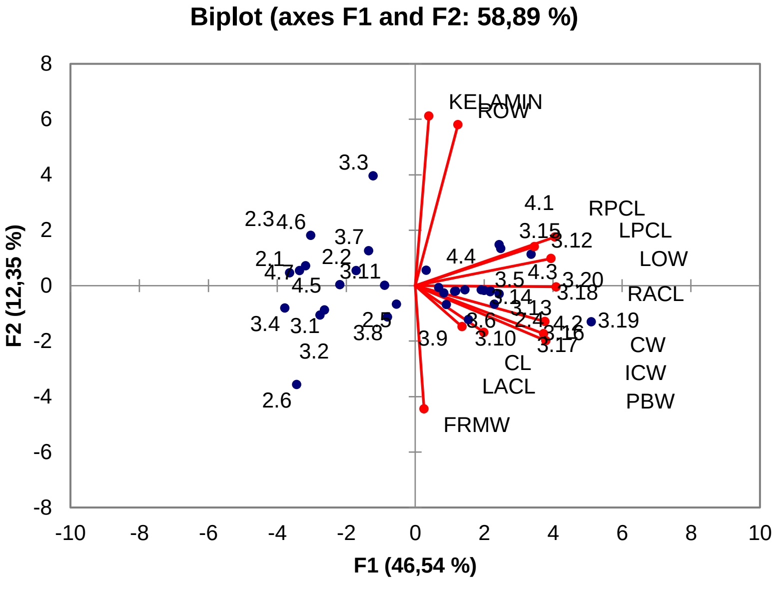

Figure 4. The results of principal component analysis (PCA) distribution of crab morphometric characters based on research stations on axis 1 (F1) and axis 2 (F2).

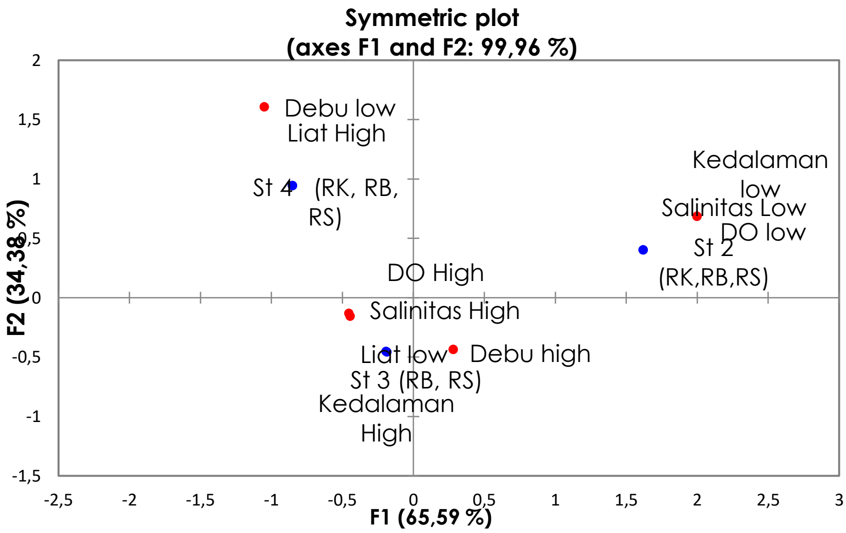

Figure 5. Correspondence factorial analysis results (Correspondence Analysis, CA) on the relationship of blue swimming crab to the characteristics of the waters at each station on axis 1 (F1) and axis 2 (F2)

In addition, the availability of feed at station 3 is also influenced by the condition of the mangrove ecosystem, which supports crab growth and provides food and habitat for crabs. High salinity and dissolved oxygen (> 7.9 mg/l) supported the crabs' survival at station 3, which was reinforced by the presence of many males, where more energy was used for weight gain than for carapace growth.

CONCLUSION

The condition of Candi Waters in Pamekasaan Madura Regency is still in good condition for swimming crabs. The abundance of swimming crabs in the waters of Candi Pamekasaan Regency was low and dominated by male and medium-sized crabs. Blue swimming crabs generally spread in waters with adequate food sources, a silt clay substrate, and high depth and salinity (> 28 ppt).

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